Safety Challenges in Construction of Kochi Metro Rail Project & Its Control

and

Studies on Safety Engineering Aspects of Nisargruna Biogas Technology

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Safety Challenges in Construction of Kochi Metro Rail project & Its Control and Studies on Safety Engineering Aspects of Nisargruna Biogas Technology

Dissertation submitted in partial fulfillment

of the requirements of the degree of

Master of Technology

in

Safety Engineering

by

Arin Manna

(Roll Number: 214CH2471)

based on research carried out

under the supervision of

Dr. P. Balasubramanian

May, 2016

Department of Chemical Engineering

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Department of Chemical Engineering
National Institute of Technology Rourkela

May 13, 2016

Certificate of Examination

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We the below signed, after checking the dissertation mentioned above and the official record book (s) of the student, hereby state our approval of the dissertation submitted in partial fulfillment of the requirements of the degree of *Master of Technology* in *Safety Engineering* at *National Institute of Technology Rourkela*. We are satisfied with the volume, quality, correctness, and originality of the work.

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Supervisor's Certificate

This is to certify that the work presented in the dissertation entitled *Safety Challenges in Construction of Kochi Metro Rail Project & Its Control* and *Studies on Safety Engineering Aspects of Nisargruna Biogas Technology* submitted by *Arin Manna,* Roll Number 214CH2471, is a record of original research carried out by him under my supervision and guidance in partial fulfillment of the requirements of the degree of *Master of Technology* in *Safety Engineering*. Neither this dissertation nor any part of it has been submitted earlier for any degree or diploma to any institute or university in India or abroad.

_____

P. Balasubramanian
Assistant Professor

Declaration of originality

This is to certify that the work presented in the dissertation entitled Guidelines for Formatting Dissertation submitted by Arin Manna, Roll Number 214CH2471, is a record of original research carried out by him under our supervision and guidance in partial fulfillment of the requirements of the degree of Masters in Technology in Safety Engineering. Neither this dissertation nor any part of it has been submitted earlier for any degree or diploma to any institute or university in India or abroad.

I am fully aware that in case of any non-compliance detected in future, the Senate of NIT Rourkela may withdraw the degree awarded to me on the basis of the present dissertation.

May 13, 2016 Arin Manna

NIT Rourkela

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Arin Manna

Nomenclature

Definitions:

i. The use of ‘shall’ indicates a mandatory requirement.
ii. The use of ‘should’ indicates a guideline that is strongly recommended.
iii. The use of ‘may’ indicates a guideline that is to be considered.
iv. SHE means Safety, Health & Environment.
v. NIOSH means National Institute Of Occupational Safety And Health
vi. OHSAS means Occupational Health & Safety Advisory Systems: 18001, 2007.
vii. OHSMS means Occupational health & Safety Management Systems: 18001, 2007.
viii. OHSM means Occupational Health & Safety Management.
ix. Direct Employee: Employees who are on Company’s pay role.
x. Indirect Personnel: Personnel who may be engaged for and/or in connection with the operation/activity of the Company but are not on Company’s pay role
xi. Hazardous waste: Any waste by means of its characteristics may cause danger to health or environment. Example: used oil, waste oil, oily soaked jutes, filters, paint sludge, paint/oil contaminated barrels, sludge from wet scrubber.
xii. Biological egents:-microorganisms that can cause infections or have sensitizing or toxic effects in humans.
xiii. ISO means International Standards Organisation
xiv. OSH means Occupational Safety Health
xv. Policy means a statement of Intent, and is implemented as a procedure or protocol.
xvi. Safety Policy means a written statement by an employer stating the company’s commitment for the protection of the health and safety of employees and to the public.
xvii. BARC means Bhaba Atomic Research Center.

Safety Challenges in Construction of Kochi Metro Rail Project & Its Control

Arin Manna

Abstract

Rapid transportation system becomes a significant factor for the developing country. Apart from that it is very essential to control the traffic in the high dense and populated country like India. So this where the need of metro rail is generated. A metro project is carried out in kochi, kerla under Delhi Metro Rail Project. L&T is one of the client of DMRC in that project. This thesis work is carried out for a part of kochi metro project. In the present scenario, in India maximum accident occurs in construction industry as the Indian construction company is lacking a huge with updated safety instrument and lack of knowledge about safety. Lersen and toubro is a big multinational Indian construction company. This studies is deals with the safety policies, there work environment, responsibilities of a safety personnel in L&T company. L&t company has a very strict and well defined safety rules which follows BIS standard, OSAH standard and BOCW. The duty of safety engineer is to look after whether any activity, in the site or out of the site, related to the project is going safely or not. It has to be checked by safety personnel as well as the engineer whether any work is following the safety integral management system of the company.

Key word: Kochi metro rail project, OSAH, BOCW

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Chapter 1

Introduction

Kochi with its wealth of historical associations and its unique setting reflects the eclecticism of Kerala. It is one of India's important ports and a major naval base. Kochi metro is elevated under constructed metro project in the city of Kerala. It has been started to construct from 2012 and planned to finish this project by June 2016. This metro project is carried out by Delhi Metro Rail Corporation. And a big part of civil work of this project is carried out by Larsen and Tourbo ltd.

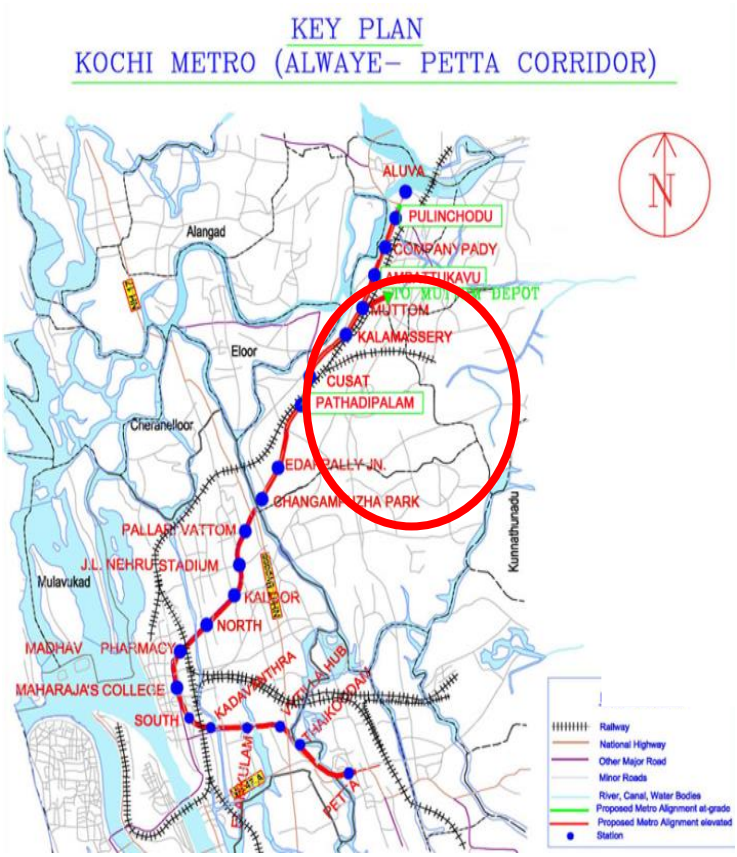


Fig 1.1 Road map of Kochi Metro Rail Project

This is the road map of kochi metro rail project. This studies is deals with the marked area named as Kochi Metro Project KC-02. This is ar7.6 km long and total 6 stations are covered under this package.

1.1 Aim of the project

To study the safety policy and challenges of a construction work and carry the responsibilities of a safety engineer.

1.2 Objective

i. To understand the safety policy of L&T Kochi Metro Project.
ii. To Determine Broad Parameters of EHS Management at site.
iii. Identify highly hazardous operations within the scope of work and specify integrated preventive measures to mitigate the same.
iv. To ensure compliance with relevant applicable legislation.
v. Continual EHS performance improvement by directing focus on the key areas for improvement in a consistent manner.

1.3 Need of metro

i. Day by day the population is increasing in our country and with that unprecedented personal vehicle also becomes an important concern. Mass transport system like metro helps to prevent the tendency of use of personal vehicle.
ii. Pollution is also an important apprehension now a days. So any invention or convention now is modified to pollution free. Metro rail transport system satisfy that need.
iii. At the peak hour it is really tough to maintain the traffic at highly populated city. So to overcome this traffic challenge metro rail is a good option.
iv. It is also time saving.
v. It consumes very less amount of fuel.

1.4 Advantage of metro system

i. It requires $1/5^{th}$ energy per passenger per kilometer compared to road based transport system.
ii. It causes very less noise, no air pollution. So it is very eco-friendly transport system compared to any others.
iii. It occupies no road space if it is underground and only 2.6 meter width of the road if it is elevated.
iv. It reduces the journey time.

Chapter 2

Literature review

2.1 Introduction

As the population of India is increasing day by day traffic control becomes a significant challenge for the government. In fact the space is limited, so the traffic accident rate is also increased day by day. This challenge is confronting the administration of india is the search of proper solution for trffic management. If we see the developed country, most of the people even who has ability to effort personal vehicle, is using public transport or mass transport system. Due to various advantages metro is considered as the best rapid mass transport system.

2.2 Construction sequence

2.2.1 Road diversion and barricading

First a regulation is implemented for the traffic for 1 lane movement in each side for a length of 200 meter between two stations. Mark the road both side at 4 meter distance from the divider. Barricade the area properly with caution board and restrict the unauthorized entry. All the light post is removed then from divider and dismantle the median. Before excavating the lane or area is to be checked for any underground obstracle.

2.2.2 Piling

Piling is done where the strata is not strong enough to sustain the load. Fig 2.1 shows the piling machine. At the bottom of the piling arm, the cutter, dig the soil and put an iron pipe there.

Fig 2.1 Piling machine

This pipe act as mold box. The desired reinforcement is done before the concreting. After concreting is left for 4-5 days putting a load on the piling to make it more stronger. When the desired strength is achieved a pile cap is constracted to make a base on the ground for further construction.

2.2.3 Pier construction

Above the pile cap reinforcement is carried out for pier. Cross section of the pier can be round of 5 ft. dia and 5*4 ft. cross section if it is rectangular. Round pier is generally used for the single pier and rectangular cross-section is used for the extended pier and in station beam. At the bottom of the pier a protector is provided for the sock resistance.

Fig 2.2 Pier

So that it protect the base of the pier. A pier cap is mounted then on the pier. Pier cap is pre casted in the casting yard. Fig 2.2 is showing the completed pier along with pier cap. Weight of the normal pier cap is around 70 ton.

2.2.4 Girder erection

This is the final stage of civil construction of elevated metro rail. Two type of girder is used there in order to the limitation of space for the crane. The girder length is also vary like 25 meter, 23 meter and 22 meter. As shown in fig 2.3 the cross section can be ‘U’ or ‘I’. Weight of each girder is around 140 ton. Erection of girder is the most critical movement of whole construction. Two crane of 150 ton capacity is engaged for one girder erection. Fig.. shows the elevation sketch how the girder is erected. The trailer to convey the girder from casting yard to the erection site, is having around 36 meter long. And the

maximum speed to travel is around 3-4 km per hour. This operation is done when the traffic is very light or mostly at night.

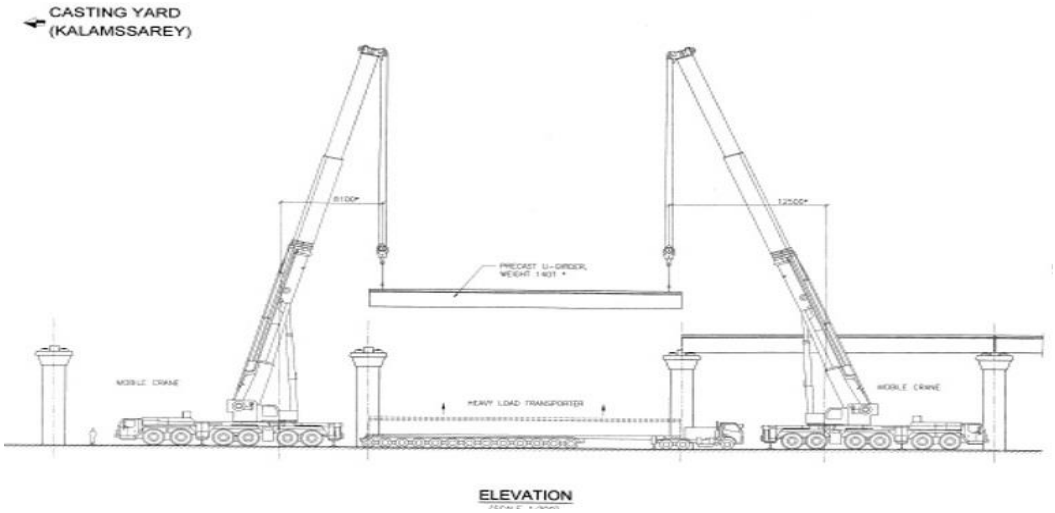


Fig 2.3 Girder erection

2.3 Work permit system

2.3.1 Objective

The Work Permit Systems are designed and intended to specify adequate safety measures in advance against identified hazards and stipulate implementation of the said safety measures by the permittee to ensure safe execution of work in the designated workplace

2.3.2 Scope

Sr.no	Scope	IMS Format
1	Carrying out Hot work in specified location	IM-14-B
2	Excavation work	IM-14-C
3	Working at Height- If Height More than 2 Mtrs	IM-14-I
4	Working on Plant, Machinery or any other Power driven equipment	IM-14-E
5	Carrying out Electrical work	IM-14-F
6	Confined Space	IM-14-A
7	Lift permit- for lifting of manbasket	-

8	Tandem Lift permit – for lifting of segment using gantry crane	-
9	Permit for segment transportation	-
10	Permit for transportation of Toll tunnel blocks	-

2.4 House-keeping

Good housekeeping is an important element of accident prevention. It is defined as "A place for everything and everything at its place". Housekeeping is done as a part of the daily routine with cleanup being a continuous procedure. Over all High standard of housekeeping will be maintained at site.

Continuous monitoring will be done to ensure the Implementation of House Keeping Plan.

Storage areas: All materials are maintained in neat stockpiles in well-laid aisles and walkways for ease of access. Care is taken there is no projections along the walkways and projections are rectified immediately.

Work areas: Loose materials, scrap and tools etc. are stored properly in the working areas especially in the vicinity of ladders, ramps, and stairs. This is strictly followed at heights where loose materials are liable to fall down. Spills of oil and grease are removed immediately. Suitable dustbins are provided at the work areas to prevent loose pieces of waste and scrap pieces lying dangerously at heights.

Protruding nails shall be removed from wooden pieces regularly and collected it properly to dispose in designated area. Other fabrication wastes like cut pieces, scrap etc also to be collected and moved to scrap yard for proper disposal.

Spillage control: Chemicals/ spillage /other hazards wastes generated at site shall be collected and stored at designated area till properly disposed off.

In no point of time, wastes or effluents shall be let to or disposed near water sources. Only effluents having discharge limits within the specified limits shall be let to rivers. Otherwise suitable accepted disposal methods shall be used.

Chapter 3

EHS policy:

3.1 Introduction:

L&T ECCD Infrastructure IC Senior Management provides demonstrable management leadership and commitment through active participation in EHS activities.

Their leadership and commitments translate into necessary resources to develop, operate and maintain L&T ECCD Infrastructure OC EHS Management System and to attain EHS Policy and legal requirements.

We are committed to manage all its activities, risks to 'As Low As Reasonably Practicable' (ALARP).

3.2 Visibility

The management will provide strong demonstrable visible leadership and commitments towards EHS by personal example and action. The Management will participate in EHS meetings, conduct site Inspections and EHS Audits, to encourage a positive attitude towards EHS. The detail of responsibilities is shown in below table 3.1.

No	TASK	ACTION BY	COMPLIANCE TARGET	VERIFICATION DOCUMENT
1.	Project EHS Committee Meeting (Review performance against EHS plans, EHS Objectives & targets and any EHS issues)	PM / CM	Min Frequency : 1 month	Minutes of Project EHS Committee Meeting – IM-10-B
2.	Project EHS Committee Inspection	EHS Committee	Min Frequency : 1 month	EHS Inspection Report, IM-09-B

		Members		
3.	EHS Review	Cluster Heads	During their Site Visit	Minutes of Project EHS Committee Meeting – IM-10-B
4.	Internal EHS Audit	MR	Once in Six Months	Audit Report including NCRs, & Site Observation
5.	Motivation Giving Safety Certificates, with token gift to the "Best safety conscious personnel" of the month to recognise good EHS practices.	PM / CM	Monthly	Copies of Certificates

Table 3.1

3.3 Proactive target settings

The project management demonstrates pro-activeness in target setting, which is shown in detail in following table 3.2.

No.	**TASK**	**ACTION BY**	**COMPLIANCE TARGET**	**VERIFICATION DOCUMENT**
1.	Jointly develop and discuss improvement targets and indicators for each location with Construction Managers & EHSO. (eg. Training of Workmen – Coverage, Inspection Compliance etc.)	PM / CM	Every Quarter	MOM of Project EHS Committee Meeting

2.	Jointly review the Incidence rate of First Aid Cases and set a target for reduction.	PM / CM	Every Quarter	MOM of Project EHS Committee Meeting
3.	Management involvement in Accident review and target setting.	CH / BU-EHSM	As required / Monthly	Investigation Report

Table 3.2

3.4 Company culture

The management seeks to create and sustain a Company culture in which employees share a commitment to EHS.

No.	TASK	ACTION BY	COMPLIANCE TARGET	VERIFICATION DOCUMENT
1.	Put EHS as the "First agenda" of all review meetings at Headquarters, BUs, Clusters & projects	EVP / BU Heads / CH / PM / CM	All time	MOM
2.	**Empowerment to Stop Work** Employees are empowered to stop work when the situation warrants immediate action in view of imminent danger to life / property / environment. PM must appreciate and reward those employees whose prompt action helps avoid potential incident.	All	All time	Verbal Verification

Table 3.3

3.5 Applicable legal and other requirements

The following acts is considered as the standards and any safety policy taken by the company is referred from that standards and satisfied those.

Sl. No	**List of Applicable Legal and Other EHS Requirements**
1	Building and Other Construction Workers' (Regulation of Employment and Conditions of Service) Act, 1996 & BOCW Gujarat Central rules,1998
2	Petroleum Act 1934 & Petroleum Rules 2002
3	Motor Vehicles Act, 1988
4	India Road Congress Code IRC:55-2001 " Guidelines on Safety in Road Construction
5	The Public Liability Insurance Act 1991 and Rules 1991
6	Explosives Act 1884 & Gas Cylinder Rules 2004
7	Minimum Wages Act, 1948 and Rules 1971
8	Child Labour Act, 1970 and Rules 1971
9	Indian Electricity Act 2003 & Rules 1956
10	Gas Cylinder Rules 2003
11	Air (Prevention and Control of Pollution) Act, 1981
12	Water (Prevention and Control of Pollution) Act, 1974, Rules 1975
13	The Noise Pollution (Regulation and Control) Rules, 2000
14	CPCB Regulations : System & Procedure for Compliance with Noise limits for Diesel generator set.
15	Workman compensation act.

Table 3.4

3.6 General EHS rules

1. No Workmen below 18 Years and above 55 Years Of age shall Be Engaged For Job.

2. All Workmen Shall Be Screened Before Engaging Them On The Job. Physical Fitness Of The Person To Certain Jobs Like Working At Height Or Other Dangerous Locations To Be Ensured Before Engaging The Person On Work. The Final Decision Rests with the Site Management to Reject Any Person on the Ground of Physical Fitness.

3. Smoking Is Strictly Prohibited At Workplace.

4. Sub-Contractors Shall Ensure Adequate Supervision At Workplace. They Shall Ensure That All Persons Working Under Them Shall Not Create Any Hazard To Self Or To Co-Workers.

5. Nobody Is Allowed To Work Without Wearing Safety Helmet. Chinstrap Of Safety Helmet Shall Be Always worn.

6. No One Is Allowed To Work At Or More Than 2m Height Without Wearing Safety Harness And Lanyard Of Harness Shall Be Anchored To Firm Support Preferably At Shoulder Level.

7. No One Is Allowed To Enter Into Workplace And Work At Site Without Adequate Foot Protection.

8. Usage Of Eye Protection Shall Be Ensured When Workmen Are Engaged For Grinding, Chipping, Welding And Gas-Cutting. For Other Jobs, As When EHSO Insists Eye Protection Shall Be Used.

9. All PPE Like Shoes, Helmet, Safety Harness Etc. Shall Be Arranged Before Starting The Job As Per Recommendation Of EHSO. PPE Non-Compliance May Attract Penalty.

10. All Excavated Pits Shall Be Barricaded And Barricade To Be Maintained Till The Backfilling Is Done. Safe Approach Shall Be Ensured Into Every Excavation.

11. Adequate Illumination At Workplace Shall Be Ensured Before Starting The Job At Night.

12. All The Dangerous Moving Parts Of The Portable / Fixed Machinery Being Used Shall Be Adequately Guarded.

13. Ladders Being Used At Site Shall Be Adequately Secured At Bottom And Top. Ladders Shall Not Be Used As Work Platforms.

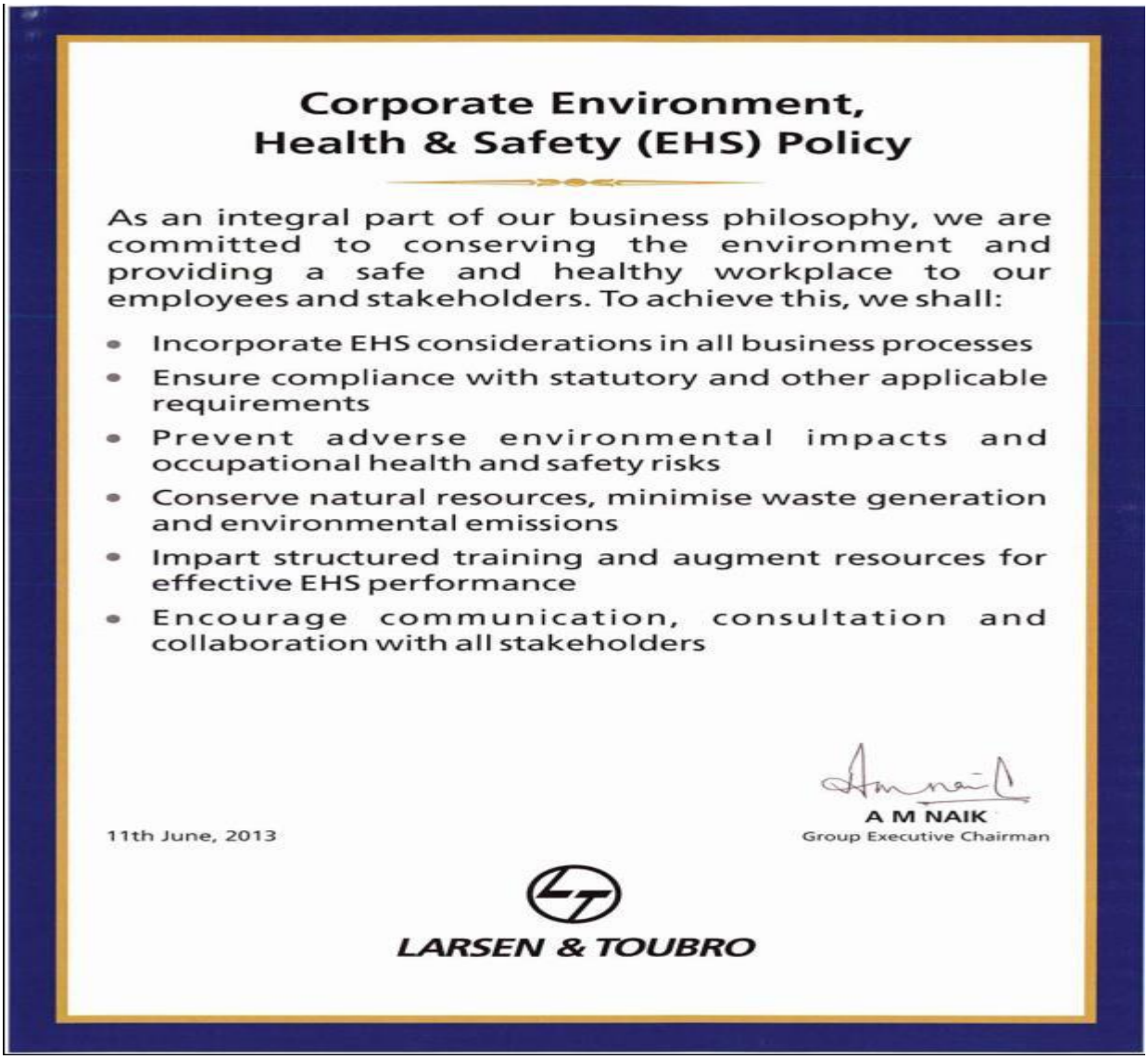
14. Erection Zones And Dismantling Zones Shall Be Barricaded And A Signalman To Be Posted To Ensure That Nobody Stands Under Suspended Load.

15. Horseplay Is Completely Prohibited At Workplace. Running At Site Is Completely Prohibited, Except In Case Of Emergency.

16. Materials shall not be thrown from heights in any case.

17. Only authorized person are allowed for Welding and Gas cutting work.

3.7 EHS policy



Corporate Environment,
Health & Safety (EHS) Policy

As an integral part of our business philosophy, we are committed to conserving the environment and providing a safe and healthy workplace to our employees and stakeholders. To achieve this, we shall:

- Incorporate EHS considerations in all business processes
- Ensure compliance with statutory and other applicable requirements
- Prevent adverse environmental impacts and occupational health and safety risks
- Conserve natural resources, minimise waste generation and environmental emissions
- Impart structured training and augment resources for effective EHS performance
- Encourage communication, consultation and collaboration with all stakeholders

11th June, 2013

A M NAIK
Group Executive Chairman

LARSEN & TOUBRO

3.8 Responsibilities of EHSO

NO.	TASK	TARGET	VERIFICATION DOCUMENT
1.	Disseminate and Communicate L&T ECCD EHS Policy, EHS Management System requirements to site personnel.	Project Duration	-

2.	Provide necessary advice, information and support in the effective implementation of the EHS Management System requirements and this EHS plan.	Project Duration	-
3.	Updating the EHS Plan to the requirements of the activities being carried out when there is a revision.	Project Duration	EHS Plan
4.	Plan and conduct Internal EHS training programs, initiate drive to promote EHS awareness and performance	Project Duration	EHS Training Records
5.	Carry out EHS inspection of Work Area, Work Method, etc. as per the ISO requirement.	As per Monthly Activity Plan	EHS Inspection Report
6.	Creating EHS awareness through PEP talks.	Every day	PEP talk Report
7.	Advising line management in preparing EHS Risk Assessment (HIRA) for the critical activities.	Project Duration	Risk Assessment Record
8.	Conduct investigation of all accidents / dangerous occurrences & recommend appropriate corrective measures.	When reported	Investigation Report
9.	Convene EHS Committee meeting & minute the proceedings for circulation & follow-up action.	Min Frequency – Once in a month	MOM – Project EHS Committee Meeting
10.	Advice & co-ordinate for implementation of Work Permit Systems.	Whenever work requiring WPS is executed	Completed Work Permit

11.	Plan procurement of PPE & safety devices and inspect before use as per laid down norms.	Project Duration	As & when required
12.	Report to REHSM on all matters pertaining to status of EHS and promotional programme at site level.	Regular basis	
13.	Facilitate screening of workmen and conduct EHS induction.	Project Duration	Screening & Induction Records (PM-19)
14.	Monitoring administration of First Aid.	Project Duration	First Aid Register
15.	Conduct Fire Drill, Procure, inspect and arrange to maintain Fire Extinguishers.	As scheduled in the monthly activity plan	Fire Drill Register
16.	Organise campaigns, competitions & other special emphasis programmes to promote EHS in the workplace.	As and when required	Record of Safety Campaign & Competition
17.	Register Customer complaints and take corrective action.	Project Duration	Customer Compliant Register
18.	Record, analyse and cascade lateral learning points from First Aid Cases, Near Miss Cases & Accidents to all project personnel and analyse the trends & effectiveness.	Monthly	First Aid Register; Accident Investigation Report
19.	Maintain all EHS related documents Update EHS training records	Continues	EHS related Documents

Table 3.5

3.9 EHS risk assessment

3.9.1 Scope

This procedure is applicable for all offices, project sites and operations globally. EHS Risk Management shall cover:

i. All routine and non-routine activities
ii. Activities of all personnel having access to the workplace (including contractors, visitors)
iii. Facilities at the workplace (eg. office, canteen, workmen facilities etc)

3.9.2 Purpose

L&T's Risk management process is applied through the five steps to risk management and is the key driver for risk control in business:

i. All relevant parties including construction & EHS teams must be involved in risk assessments and the risk management process;
ii. Risk assessments & Safe Work Method statement must be developed and approved prior to any work activity starting;
iii. All Identified risks and risk mitigation plans must be documented, approved and simply communicated to all parties.

Chapter 4

EHS challenges and initiatives to control

4.1 Introduction

The metro project work is constructed on the busy road. So safety precaution of the worker and the engineer along with the public is significant concern of the project. Due to the heavy traffic during the pick hour as the road where is it being constructed, is connected to national highway, so many limitations come during the construction. This challenge confronting all the safety personnel along with all the employees to adopt a safety policy and to apply the control measures to minimize the probability of risk or the impact of undesirable EHS consequences. Risk control measures that have been implemented and are still effective in controlling the hazard.

4.2 EHS challenges

i. Traffic Management i.e working on live traffic while Barricading boards Installation & Cleaning.
ii. Space constraint.
iii. Work at height including, Station work, Pier cap erection & U-Girder erection.
iv. High Workmen Rotation.
v. Managing Union workmen

4.3 control measures

Following the safety policies the initiatives taken by the company to overcome the above challenges are

i. To manage the traffic control, at every 200 meter a traffic marshal is employed. Apart from that to avoid the accident a stong barricading is provided at the both side of work place. The proper deviation and caution board is also provided. For the night all the deviation sign and the caution board are written with light reflective materials as shown in fig 4.1

fig 4.1 barricading and diversion.

ii. Project EHS Department in co-ordination with assigned trainer will conduct Safety training programs on different topics. Project Manager, Section in charge, Site engineers, supervisors & workmen attend the program to enhance their technical knowledge with respect to safety and learn how to integrate safety into the work-practices. It is compulsory for all staff members to attend this programme at least once as early as possible from the date when they joined in company service. Apart from training program everyday morning toolbox talk is given at the site by the engineer in presence of safety officer as shown in fig 4.2

Fig. 4.2 tool box talk.

iii. All the excavated area generated due to piling work is barricaded with the caution board.

iv. Prper housekeeping is carried out every time to main the the workplace clean.

v. To prevent fall from height and the materials falling two layer of safety net is to provided. Apart from that if anywhere any work is carried out at hight a caution board is given to make aware from the material fallings. As per the regulations all the workers are working at height must be provided the required ppes.

vi. In every month noise, dust particle at the work premises, illumination, air contaminant is checked whether it exceeds the standards or not. To prevent the dust water sprinkler is spread to the road nd the working place as shown in fig…

Fig 4.3 Water sprinkler.

vii. Various types of colorful posters are provided beside the road to increase the safety awareness. Apart from that the every year some award is given to the worker or engineers for proper motivation.

Chapter 5

Reports

I have been working there as a trainee safety engineer for 5 months. In this stipulated duration my work plan detail is given bellow.

Some sample reports prepared by me:

Project EHS inspection report between muttom to kalmassery station.

LARSEN & TOUBRO LIMITED

INFRASTRUCTURE INDEPENDENT COMPANY

PROJECT EHS INSPECTION REPORT

Name of Project: KMRL KC-02

Business Unit : Metros & Defence Area / Location Inspected : MUTTOM P

TO: PROJECT INCHARGE	Date-14/8/2015	INSPECTED BY: RJ,SN			
Sl no	EHS observation	Action required	Action by	Target date	Remarks
1.	material storage is improper 	Do Proper housekeeping and stack materials in designated place.	JP	19/08/15	
2.	Inspection data is not written	Fill up the			

	  improper placement of ladder P177	green card properly with permanent marker	NR	W.I.E	
3.	 Access blocked to the staircase and improper storage of materials	The ladder should be extended at least 1 meter above the landing platform.	Bhanskar	W.I.E	Closed
4.					

		Access to clear and unwanted debris to be removed from site.	JP	19/08/ 15	
5.	Concrete debris are hanging up on the net. 	All the concrete debris and loose materials have to be removed from the net.	JP/ M/sGC C	W.I.E	
6.	Open pit beside the road. 	provide hard barricade with caution board.	JP	W.I.E	

7.	misuse fire extinguisher.  No safety net P	Keep the fire extinguisher properly at proper place.	JP	18/08/15	
8.	 Improper base of scaffolding.	Wrap safety net properly.	PK	W.I.E	
9.		Provide proper base	JP	W.I.E	complied
10	Stagnant water, unhealthy condition.				

.		Stagnant water has to be drained from the pit.	JP	20/08/15	
11.	accessto p.d.b box is blocked.  	Provide prope access to pd.b box.	JP	19/08/15	
12.	 No protection from public vehicle				

		Provide crash barrication or barricading			
Signature of EHSO :		**DATE:**	**Report Sent to:**		

EHS inspection report of a inspection in casting yard.

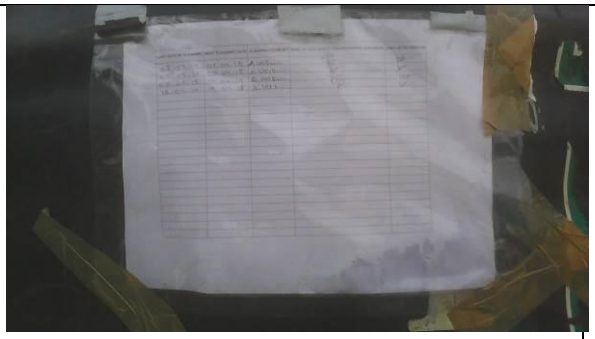
LARSEN & TOUBRO LIMITED
INFRASTRUCTURE INDEPENDENT COMPANY

PROJECT EHS INSPECTION REPORT

Name of Project: KMRL KC-02
Business Unit : Metros & Defence Area / Location Inspected : MUTTOM P

TO: PROJECT INCHARGE	Date-14/8/2015	INSPECTED BY: RJ,SN			
Sl no	EHS observation	Action required	Action by	Target date	Remarks
1.	Concrete debris are stored in casting area. 	Remove concrete debris from casting area.	PK/AM	WIE	
2.	Improper storage of stressing strand, ply wood	Cover the stressing	PK/A		

		strand and store it properly. Keep clean walk way.	M	15/10/15	
3.	Poor housekeeping used/damaged metal scrubs are thrown. 	Proper housekeeping to be done.	PK/AM	15/10/15	
	Sparks flown on flammable material & cloths 	Remove cloths and other flammable materials.	PK/AM	WIE	Closed
4.	Drinking watertank cleaning not done	Tank to be cleaned	SRA	WIE	

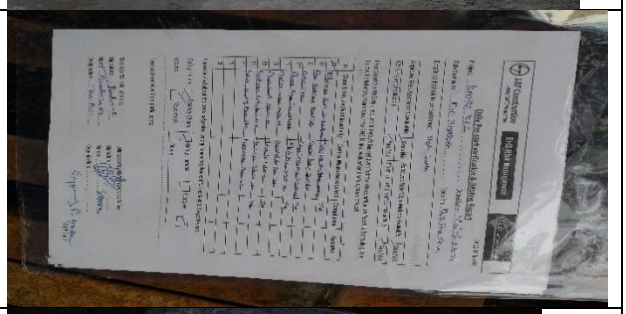
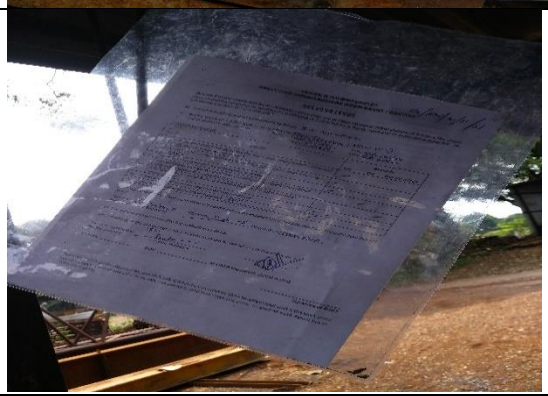
	 Damaged panel board cover in steel yard	Replace damaged cover	PM	07/10/15	
5.	 Improper barricading 	Provide continuous barricading throughout track area	PK/AM	10/07/15	
6.	 Nozzle of fire extinguisher is damaged	Replace the fire	SN	WIE	

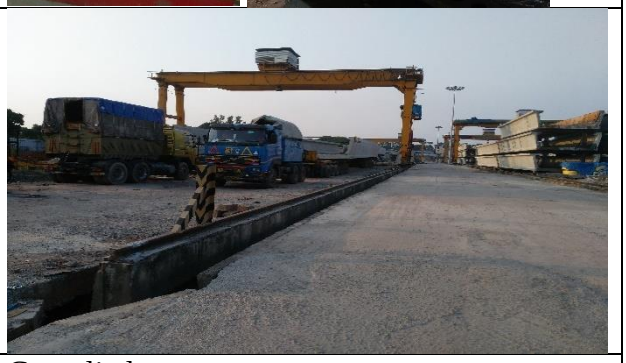
7.		extinguisher.	PRG/ NR	WIE	
8.	No green card, making noise and vibrating.  No barricading. 	Repair the machine and stick green card. Provide proper barricading with caution board.	PRG	10/10/ 15	
Signature of EHSO :		**DATE:**	**Report Sent to:**		

Compliance report of a casting yard:

Compliance report for EHS inspection report dated 19/09/2015

1.	Hand protection not provided while handling grease & Petrol	Complied

2.	Improper cable routing at Bay1 & Bay2 front side	
3.	Poor house keeping used/damaged hand gloves are kept all across casting beds	
4.	Used hand gloves not disposed from site near steel yard	
5.	Drinking watertank cleaning not done	
6	Used Strands pieces stacked on walkway	
7.	Gas cutting activity is carried but PSVB mentioning control measures for welding	
8.	Same person signing permit for issuing engineer & Section incharge	

9.	Unauthorised operator for powerpack	 
10	Used/damaged tyres stored at end of bay	
11.	Persons standing under suspended load for cleaning inner shutter	Complied

Minor Incident Report

PART A – TO BE FILLED BY SITE ENGINEER		
1. Details of the Project		
Name of the Project & Job Number: KMRL, KC-02 LE-130309		Business Unit: MND
2. Category of Incident (Tick as applicable)		
Part 2 Minor Incidents	Category 6	☐ First Aid Case
	Category 7	☒ Near Miss Case
	Category 8	☐ Minor Environment

3. Details of the Incident (Write N.A if not applicable)

Name of the Injured	**Age**	**Sex**	**Designation**	**Date of Joining**	**Date of EHS induction**
N.A					
Date & Time of Incident:	**24/11/2015 at 3:00 pm**				

3.2) Exact Location where the Incident occurred: HMT pc yard bay 3**.**

3.3) Injury details : N.A

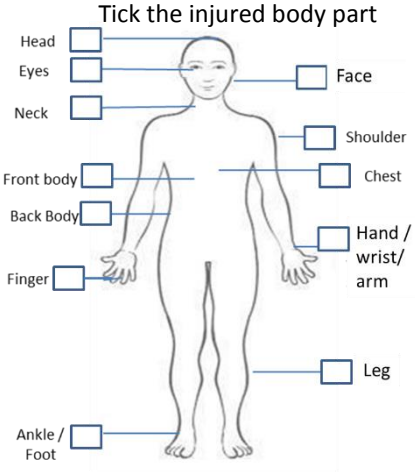
3.4) Name / Identity of the P&M / Equipment :

Asset Code: _____ Registration No: _____ Owned by: L&T ☐ Subcontractor

3.5) Describe briefly how the incident occurred:

In bay 3 a safety personnel was checking tongue buckle under the working platform of outer shutter. At that time two steel rod felled down from the working platform, just beside the safety personnel, while it was hit by a worker, passing over there.

PART B – TO BE FILLED BY INVESTIGATION TEAM

Body Part Injured	**Type of Injury**
Tick the injured body part  	Tick the type of injury ☐ Sprain/strain ☐ Poisoning ☐ Laceration / Cut ☐ Abrasion ☐ Burn ☐ Internal organ damage ☐ Stab / Penetration ☐ Others (specify)

4. Causes of the Incident

Name of the Section Incharge : Harswardhan (GET)	Signature:

4.1) Direct Causes: 1. Worker hit the bars. 2. Rebar fell down from walk way.

4.2) Root Causes: (Tick the root cause)

1. Human factors	✓	2. Physical condition	✓	3. Management System	✓
1.1 Inexperienced/ Unauthorised/ untrained worker		2.1 Wrong selection of equipment / tools.		3.1 Hazard & controls not identified previously	
1.2 Medically or physically unfit		2.2 Faulty equipment / tools (not safety inspected)		3.2 Unsafe work method / Generic	
1.3 Poor task behaviour/ shortcuts	✓	2.3 Unsafe operation / Safety devices not working		3.3 Design safety issues	
				3.4 Risk control measures not implemented	
1.4 PPE not used / worn		2.4 Poor housekeeping	✓		
1.5 Unsafe behaviour of worker (horseplay/ mobile phone usage etc.)		2.5 Poor storage of materials		3.5 Not enough training or instruction	
		2.6 Unsuitable work area (inadequate space)		3.6 Poor compliance to safety inspection	✓
1.6 Golden Safety rules violated		2.7 Unsafe Work environment (light / noise / dust / smoke/ weather condition)		3.7 Lack / incompetent supervision	
1.7 Standing & operating in unsafe position					
		2.8 Hazards originated due to external factors		3.8 Poor selection/quality/ no issue of PPE	
1.8 others		2.9 others		3.9 others	

5. Remedial Measures Action Plan

5. What are the precautions taken / being taken to prevent similar occurrence?

Immediately all the loose materials are removed and make the walkway clean.

Names of the Minor Incident Investigation Team: SRIJIT, HARSWARDHAN

EHS In-charge: JR	Signature:

Chapter 6

Conclusion

Though the Lersen and Toubro is a multinational construction company due lack of modern technology still there are some accident take place. During the stipulated time of project there was no any fatal case but some minor injuries is taking place. Even everyday some people are injured at first aid level. Safety is not a responsibility of any particular person or only the safety engineers. From the very first day when a employee employed, he is advised to take care of own safety himself. This is really tough to make a site totally injury free but not impossible.

L&T is updating its safety policy or EHS management system to make a project totally accident free. Safety become their first concern and they provide more layer of protection to prevent the risk at the workplace.

In this project the main challenges were height work, and traffic management. L&T is successfully takle those challenge by implementing new technologies and established fluent communication system. Through different report and punishment for in-compliance of unsafe work the accident rate becomes under controlled.

Safety Engineering Aspects of Nisargruna Biogas Technology

Arin Manna

Abstract

Though dumping of solid waste is very unsafe, as it misbalance the element of environment, it is very common way in the cities due to lack of technical and financial recourse to reuse the waste properly. Segregation of organic waste from the municipal solid waste stream line represents an open scope to reduce the quantity of waste using for landfills by up to 50% by weight. Nisargruna technology is developed by Bhabha Atomic Research center of India that deals with bioprocessing of any type of biodegradable solid waste in a very efficient and environment friendly way. Since National Institute of Technology Rourkela is being a home to around 6000 students per year, the disposal of hostel kitchen waste is one of the key environmental concern to be addressed. This study aimed to analyze the safety engineering aspects of Nisargruna technology for the biogas generation from hostel kitchen wastes. Any leakage of waste manure from biogas tank could affect the environment very much instantly. In addition, it might have fire, physical, and mechanical hazards etc. This biogas plant doesn't have high possibility of occurring accident. But as it is producing high flammable gas like methane and very harmful gas to human health, like hydrogen sulfide, we need to adopt a safe and proper safety policies to overcome the explosions and the health effect. Apart from that a hazop study is done to eliminate another small hazards, involved in this process. The plant is planned to construct near hostel premises. So it is necessary to evaluate the risk area and risk volume to locate the plant at a proper place so that the student will not be effected by the consequence of any accident. Another main purpose is to generate electricity using biogas. So this is need to evaluate the economic advantage by adopting this project.

Key word: Segregation, Nisargruna Technology, Biogas plant.

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Chapter 1

Introduction

Waste disposal and its handling is a big concern of the developed and developing countries nowadays. Generally the waste is disposed by means of landfill, incineration, and dumping etc. Yet, all the processes have their own pros and cons. However, the improper disposal of waste affects human health and environmental balance. Concurrently the world energy demand is also increasing day by day. This alarming situation presses the demand for sustainable solutions to address both energy and environmental sectors. So the most efficient way to waste management is utilizing biomass energy from biodegradable waste. So the government of different countries are making their legislation regarding the waste disposal, its proper management and using the biomass energy. Likewise NIT Rourkela, a prestigious educational institution, situated in odisha, is also taking the challenge of appropriate solution of the waste disposal by producing electricity from biogas energy. A biogas plant of 2MT input capacity is planned to install in the premises with a motto of using renewable energy. As an outcome from the brief survey at the hostel discloses that around 1000 kg of food waste are being generated in the campus daily. Apart from that there are also a few amount of dry leaves and grasses are coming out as waste. All this wastes are sent outside for the landfill purpose or food supply to the animals. So basically there are two main objectives behind this project. One is proper management of waste and another one is supplying electricity for own use, which motivates the use of renewable energy. As it is a large scale plant going to install at the hostel premises, safety is also a non-negotiable factor here. Though biogas plant is not very much vulnerable we have to adopt a good safety policy to prevent any type of accident which can cause any harm to the students and the workers of the plant. A little mistake can cause a big loss. So by implementing proper safety policy according to the norms and regulation of OSHA and BIS regarding bio mass handling this project will be a successful one to fulfill its objective.

1.1 Aim of the project

To evaluate the safety engineering aspects of biogas plant using nisargruna technology in a large scale

1.2 Objective

1. Develop proper solid waste management in NIT Rourkela campus
2. Explore the safety aspects of Nisaragruna technology

1.3 Purpose of the project

The main purpose of the biogas plant following nisargruna technology is as follows:-

1 The whole process is environment friendly in order to disposal of waste, the need of the hour.

2 To generate a rich amount of biogas fuel, which will definitely support the declining energy resources. As well as the gas can be used for as fuel in power generation and in kitchen purpose also.

3 Generation of rich quality, weed free manure, which is enrich the soil conditioner for fertilization. This is significantly important for replenishing organic carbon in the undernourished soil after years of agriculture.

Chapter 2

Literature review

2.1 Introduction

BARC's NISARG-RUNA plant for solid waste management offers a Zero garbage, Zero effluent method for waste management. Two such plants have been installed at BARC and the residential complex, Anushaktinagar, for environmental friendly disposal of the waste generated in kitchens of various canteens in the premises.

A substantial portion of our biodegradable waste is food waste (38-40%) which is used to generate methane. This methane gas can be used as fuel for domestic kitchen purposes or in vehicles. The food waste and paper waste can also be considered as manure. Manure obtained from such waste generally contain nitrogen contents. That's why this manure can be used as excellent soil conditioner. The plant returns as organic manure that is 10% of the total waste processed. For a fertile land the carbon to nitrogen ratio should be 12:1 and this type of manure satisfy that. It contains magnesium, potassium, phosphorus and iron in small quantities. It is completely weed-free and does not have any foul smell.

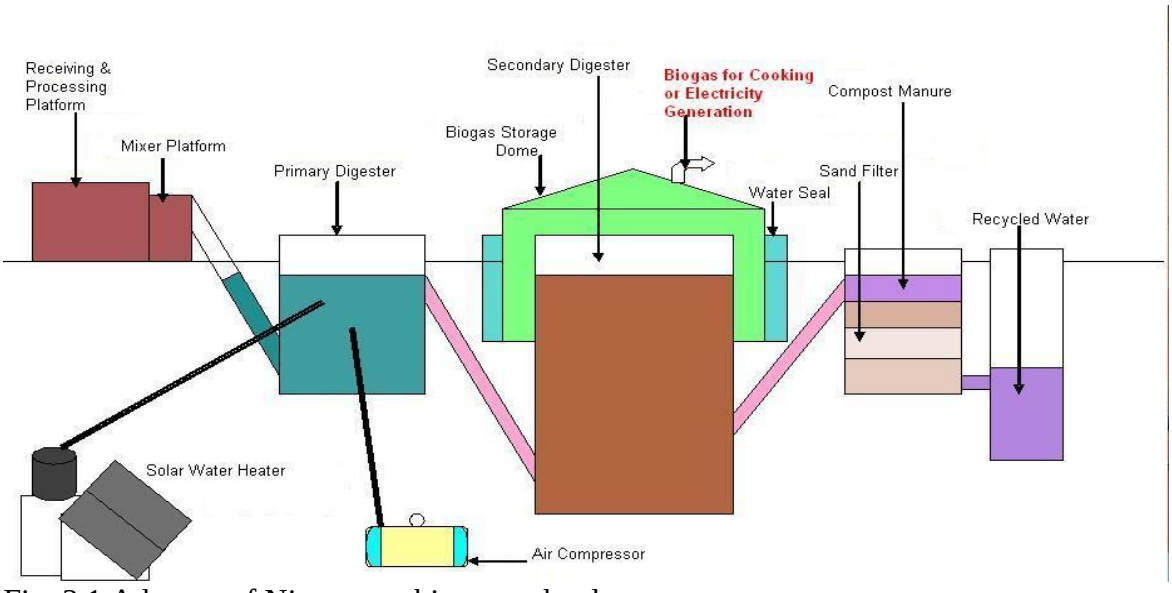

Fig: 2.1 A layout of Nisargruna biogas technology.

2.2 Technical details of the plant

Major components of BARC's a Nisargruna plant include a mixture/pulper with motor(s) for crushing solid waste, a pre-mix tank, a pre-digester tank, an air compressor, a slow water heater or solar panels, a main digestion tank, a gas delivery system, manure pits, a tank for recycling water, a water pump, slurry pump and a gas utilization system. The waste is homogenized in a mixer using water. This slurry enters the pre-digester tank where aerobic thermophilic bacteria proliferate and convert part of this waste into organic acids like acetic acid, butyric acid, propionic acid and formic acid (Dr S Kale, 2005).

2.2.1 The three steps of Nisargjyoti (biogas) production

Nisargjyoti microbes, which is consist of a large group of complex and differently acting microbe species, mainly methane-producing bacteria. The entire Nisargjyoti formation process is followed by three steps: hydrolysis, acidification, and methane formation. Different types of bacteria are accordingly involved in these processes.

Hydrolysis

This is the first step (hydrolysis) where the organic matter is enzymolyzed externally by extra cellular enzymes (cellulase, amylase, protease and lipase) of microorganisms. This step is being carried out in pre-digester tank. In this step the solid waste is converted in to the semi liquid through a mixer. Bacteria decomposes the long chains of the protein, complex hydrocarbon and lipids and make it in shorter parts. Proteins are split into amino acids and peptide. The protein and the simple hydrocarbonate are degraded entirely.

Acidification

In the second step the acidifying bacteria involved, convert the intermediates of fermenting bacteria and it produces acetic acid (CH3COOH), hydrogen (H2) and carbon dioxide (CO2) in the same pre-digester. These type of bacteria, like genus bacillus, are aerobic and facultative anaerobic, and can function under acidic conditions. An air compressor is provided to maintain aerobic conditions in the pre-digester. To produce acetic acid, the bacteria use the dissolved oxygen in the slurry solution or bonded-oxygen. Therefore, the acidifying bacteria reduce the compounds with a low molecular weight into alcohols, organic acids, amino acids, carbon dioxide, hydrogen sulphide and traces of methane.

Methane formation

In the third step, the methane-producing bacteria, decompose the compounds, produced after acidifying, with a low molecular weight. Under normal conditions, methanogenic microorganisms take place to the extent that anaerobic conditions are provided, for instance under water, in marshes and ruminant stomachs. These bacteria are anaerobic and very sensitive to environmental changes. In contrast to acidogenic and acetogenic bacteria, methanogenic bacteria belong to the archae bacteria group. Archae bacteria is a group of bacteria with a very heterogeneous morphology and a number of common biochemical and molecular-biological properties that distinguish them from all other bacterial genera. It is worthwhile to circulate the generated biogas back into the system using a small compressor. This would provide a rich quality of methane and enhance the reduction of CO_2 to methane.

Chapter 3

Case studies

3.1 Discussion

A case study is done in Odisha Power Grid Corporation for the purpose of better understanding about the nisargruna technology. In OPGC, Odisha a biogas plant of 50 kg input capacity, is running successfully following Nisargruna technology. The installation in addition to dairy cow dung manure, uses residential biodegradable waste and co-digester materials. This biogas plant, following Nisargruna technology, encompassing feedstock resources and transport. This plant is established 2004. The cow dung is imported from nearby cow stables by means of scraper system. It is left for sometimes and then collected from the cow dung pit and send to processing room for proper mixing with another raw material. Other manure like food waste dry leaves are collected from residential area every day. These collected waste are segregated in biodegradable and non-biodegradable. Though they are having a good policy for the segregation, where the segregation of biodegradable waste is done at the source. Every residence are given two different dustbin with different color code. Apart from that the drainage system is also designed in such a way that the separation of waste is one at the source. So all biodegradable waste are collected automatically in a particular place. All the collected waste and the raw manure are sent to processing room (fig 3.1) for final segregation. After the segregation the manure is feed to the crusher manually. The crusher is totally covered by metal plate cover and connected with a 7.5 hp motor. It is installed in a shaded area but sidewise open. The motor is not covered by any type of cover. So to make the waste a conditioned waste water is added, in proportion of 1:1, with the slurry materials. This process continues for 10 to 15 minute for proper mixing. At that time the ph level of sully is maintained as 6-7.5. Then the semi liquid slurry are flowed to a premix tank before the in primary digester. At that time some hot water is added to the slurry. The water temperature is around 55^0 centigrade. The water is heated by a solar water heater (fig 3.2). Primary digester is made of concrete and $20m^3$ volume. It has also a conical shaped metal cover as shown in fig 3.6. On the wall of the cover there is an indicator to understand the level of the slurry in the primary digester. As the reaction take place in primary disaster is aerobic reaction an air compressor is connected directly to the primary digester. The

manure is kept here for 3-4 days for proper acidification. After the acidification in presence of some thermophilic bacteria and microorganism the ph level of the slurry is dropped to 3. After this slurry is processed in primary disaster it goes to main digester by means of law of gravitation. In main disaster the methanogenic bacteria produce methane from the slurry. To extract the total methane gas from the slurry it takes nearly 8 days. There is a rise of gas level in the membrane that come up a maximum level of 8 feet, holding $35m^3$ of biogas. After the complete processing, the hemi cellulosic materials are conveyed to manure pits. They get transformed into rich manure (fig 3.5) which is used to enrich the soil condition in agricultural applications.

There are various factors that affect the biogas plant and its productivity. For better productivity the temperature has to be just right at around 55^0C. the bacteria functioned more perfectly in higher temperature. Once the bacteria is used it cannot be used again. Lower the temperature, the gas production becomes less and stops at 10^0C. to maintain the

Fig: 3.1 processing room.

Fig: 3.2 solar heater

Fig:3.3 maintenance work

Fig: 3.4 digester

Fig: 3.5 manure by product

Fig 3.6 membrane of two digester.

3.2 Outcome and specification

The quantity and description of the subtract

Amount of biomass (per day)	250 kg
Amount of water use (per day)	250 liter
Electricity (3.7 Kw for 30 min per day)	1.87 units
Lighting (400 watt for 12 hours)	4.8 units
Biogas from 200 kg waste	16 m^3 per day
Equivalent lpg gas produced	7.75 kg per day
Digested slurry	75 kg per day

Table: 3.1

Cost analysis:

Project cost	5,81,000
Labour cost	73000
Maintenance cost	30,000
Electricity cost for 6.67 unit	7000 per year
Water cost	1000 per year
Total	1,11,000 per year
Cost of biogas produced (compared to lpg)	1,64,000 per year
Cost of manure produced (@ rs 2/kg)	55000
Total	2,19000

Table 3.2

There are several benefits constructed the biogas plant in the premises. Solid waste management is being carried out smoothly. Apart from that the waste are also used to produce biomass energy. It is clearly seen from the table that the produced biomass energy is saving Rs 1,64,000 cost of natural resources by means of LPG gas. Apart from that a rich manure is also produced which can be applied to enrich the productivity of the soil. As well as the whole process is also eco-friendly as it is not releasing any type of pollutant gasses. So the total savings, OPGC can save from this production of rich manure and high quality biogas is about Rs 1,08,000 per annum.

Chapter 4

Questionnaires and survey

4.1 Introduction

A survey work is carried out to know the approach for the handling of waste. It is necessary to know how much the food department and the hostel cleaning persons know about the waste handling and disposal. By that means it is easy to figure out the segregation plan at the source. Segregation of wet waste is essential in order to process the solid waste management.

Some questions are asked to the head of the mess caterer, hostel warden, canteen owner and some students also to know their awareness and approaches regarding solid waste management. We have got very active interesting responses from them.it has been very easy to us todo the survey work as they are very spontaneous and enthusiasm for this solid waste management program.

4.2 Response and feedback

1. Do the students generate food waste? How much per day ?

	< 50 gm	50-100 gm	100-200 gm	>200 gm
Waste generate amount per day	10%	15%	45%	30%

Nearly everyone is generating waste per day. But the amount are varies in different hostel. We took an average value of food waste amount to make a idea how much food waste we can get from the hostel. However from the feedback we understand that average 200 gm food waste is generated per day by every student.

2. Does the housekeeper know the difference between solid waste and dry waste ?

	Yes	No
Awareness about wet waste and dry waste	75%	25%

The hostel warden, kitchen stuffs they are almost know about the wet waste and dry waste. But it is necessary to know whether the housekeepers know or not. Because they clean the hostel collect the wasted from the hostel dustbin. In case of canteen also the owner can separate wet waste and dry waste.

3. Where do the students through their waste. ?

	Hostel dustbin	Road side	Anywhere else
Disposal habit	80%	20%	0

This is very glad to know that the almost students throw their waste at proper place. There are several dustbin in every hostel at every floor. Apart from that at the campus road side also there are some bust-bins. So most of the people throw their waste at proper place. So it is very helpful to collect the waste. But during the night the students take some food from night canteen or the food shop in campus. That time mostely they through the paper of waste beside the road.

4. How is the waste collected?

Sweepers are employed to sweep the hostel premises daily. They collect the waste from the hostel dust bin at every morning. In the dining hall some dustbins are kept. The students put their food waste by themselves. There are also dustbin at every canteen and the food restaurant. All the waste including kithen waste, generated in hostel are stored in a big dustbin constructed before every hostel building. Municipality car comes to collect the waste. Apart from that there are many workers, sweep dry leaves maintain the grass, and store all this type of waste at the garbage bins situated in different pace of nit purpose.

5. Is the plastic bag used to disposed the waste ?

	Yes	No
Use of plastic bag	45%	55%

Generally non degradable plastic bags are used to dispose the waste. The wet waste are collected in plastic bag to throw it in to the dustbin. But in every hostel a good culture is adopted. They have some big bucket to use as a dustbin. All the food waste and the

kitchen waste are first thrown there. At the end of the day all the all the wasted stored in the bucket are thrown in the garbage bin at in-front of the hostel. But in canteen or other restaurant plastic bags are used to dispose any waste. Apart from that the different food product also available in plastic bag. So from there also plastic packets are generate. Recently biodegradable plastic packet is also invented and government take necessary steps to remove the use of hard plastic bags. But here still now biodegradable plastic bag is not introduced properly.

6. Do you know the separation of dry waste and wet waste? Do you like to separate dry waste before disposing it ?

	Yes	No
Knowledge about segregation	70%	30%

	Yes	No
Willing to segregate	95%	5%

To set up a solid waste management system this is essential to know whether the people, disposing the waste, know about the separation of dry and wet waste or not. The result came like all the hostel mess caterers know about the segregation. But some canteen owner doesn't know this. But it is very helpful that when the segregation process is explained to them most of the people are agreed to segregate the waste before disposing it. Though it will not be implemented or maintained at cent percent, they agreed to keep two separate dustbin for dry and wet waste.

7. Do you know what is done to garbage when it is collected from NIT ?

	Yes	No
Knowledge about the use of the garbage.	30%	70%

Knowledge about the different use of waste, like landfill, dumpsite, is not still adequate. However some caterer people know how the food waste is used.

8. Do you think NIT is doing enough to manage the waste properly?

	Yes	No
Blaming NIT for poor waste disposal	10%	90%

Most of the people are satisfied how the institution is disposing the waste materials and how they maintained their premises. Still some complain came in order to irregular service to collect the waste materials. Sometimes the dustbin or the canteens are overflowed.

9. Are you interested in installing new technology for better management of solid waste?

	Yes	No
Agree to install	100%	

Though they are satisfied with the management policies of the NIT regarding waste management they are not aware of the biogas production technology. So the advantages and brief of this technology was introduced to them, they all agreed to implement this technology.

10. Will you pay extra money to implement and maintain this new technology

	Yes	No
Willing to pay	10%	100%

Though every-one is interested to install this new technology they are not willing to pay for this. Some interested students are there, are willing to pay some amount to implement this technology.

4.3 Discussion

It is very much clear that landfill and dumpsite is not best solution for the solid waste management. In fact, at night a huge amount of electric is needed to lighten up the whole nit premises. So where the scientist and engineers are confronted for the proper way to dispose the solid waste and use of renewable energy is a big challenge, this is very essential for the prestigious institution like NIT to use biomass energy, as it is producing a

huge amount of biodegradable waste. Apart from that this institute can be motivational icon for the other developing cities and countries, where the waste material handling is a significant issue. Education is the best way to solve any problem. So it will be very fruitful for the society if this type of initiatives can be taken by the institution.

Chapter 5

Design aspects

5.1 Size of component

The main components of a biogas plant is a motor pump, crusher, two digester, piping arrangement, insulator, segregation system, air compressor and a solar water heater. On basis of the installation cost of this main component, the plant installation cost is evaluated. The following formula can be used to determine the required volume of of the primary digester.

V_D = (Mmanure + Mcs) * HRT/365

Where, V_D- digester volume

M_{manure}- mass of manure

M_{cs} – mass of additional material.

HRT – hydraulic retention time

Hydraulic retention time is defined as the time period during which the input manure stays in digester and the desired reaction is not done properly.

HRT for acidification is around 4 days and the same for methanogenic reaction is around 9 days.

The membrane or the cover of the digester depends on the diameter of the digester. The gas produced from the reaction is stored in that membrane. So the diameter of the membrane is relatively smaller than the digester. So the diameter of the digester should be-

$$D^2 = \frac{4 \times V_D}{H \times \pi}$$

Where, D = dia of storage

V_D = volume of the storage

H = height of the storage.

Same equations also go for the secondary digestion. But HRT of methanogenic is more than the acidification. Apart from that the final product i.e. methane is stored at the upper membrane of the digester. So the total size of the secondary disaster is greater than the primary digester.

The biogas, is produce after methanogenic, is stored in the membranes which cover the secondary digester. So the volume of the dome is

$$V_{BS} = \frac{V_{bio}}{365} \times 0.2$$

Where,

V_{BS}= biomass storage volume

V_{bio} = daily biogas gas production

Total area of the insulation

For wall

$A = H \times D \times \pi$

For ground

$A = D^2 \times 0.785$

Suppose we feed 500 kg at a time for crushing and mixing. So the capacity of the motor and pump is required to mix the slurry is-

Biogas yield:

No of student in the hostel(nos) = 5000

Food waste generated per day(fwg) = 0.2 kg per day

Total food waste amount, generated per day(Tfwg) = nos×fwg

= 1×10^3 kg/day

= 365.242 T/year

Making slurry out of food waste for feeding in the digester for efficient digester

Specific gravity of water(spw) = 1

Density of water(pw) = 1000 kg/m^3

Concentration of solid in the slurry(css) =50%

Volume of feeding $slurry(Vfs) = \frac{Tfwg}{spw \times pw \times css}$

= 2 m^3/day

Hydraulic residence time and solid residence time are equal HRT=SRT= 45-60 days (warm to cold)

HRT = 20 days

Volume of digester Vdig = HRT×Vfs

= 40 m^3

Volume of gas storage Vgs = 0.6×Vdig

=24 m^3

Total plant volume Tpv = Vdig + Vgs

= 64 m^3

5.2 Energy yield (MJ/day)

Enter the composition of food waste (% composition by CHNS analysis) atomic numbers are given as the list:

c = 0.4206 Ac = 12

h = 0.0575 Ah = 1

o = 0.4575 Ao = 16

n = 0.0423 An = 14

su = 0.0019 Asn = 32

net = c+h+o+n+su

= 0.98

Mass to mole conversion

Mc = (c/Ac)×100 = 3.505

Mh = (h/Ah)×100 = 5.75

Mo = (o/Ao)×100 = 2.859

Mn = (n/An)×100 = 0.302

Msu = (su/Asu)×100 = 5.938×10^{-3}

Dividing the lowest values to get the whole number ratios

MFc = Mc/Msu = 590.316

MFh = Mh/Msu = 968.421

MFo = Mo/Msu = 481.579

MFn = Mn/Msu = 50.887

MFsu = Msu/Msu =1

Nch^4mb = (MFc/2 + MFh/8 + MFo/4 + 3MFn/8 + MFsu/4) = 276.843

Nco^2mb = (MFc/2 - MFh/8 + MFo/4 + 3MFn/8 + MFsu/4) = 313.833

% of methane production:

Ch^4 % = (Nch^4mb/MFc)×100 = 46.836

Co^2 % = (Nco^2mb/MFc) =53.164

Dry matter (ts) is 70% ts= 0.70 Tfwgts= Tfwg×ts = 700 kg/day

Organic dry matter is 95% of total solids (odm) = .95*ts Tfwodm = Tfwg×odm

= 665 kg/day

Assuming 60% of carbon in the organic dry matter is biodegradable

Bdcodm = 0.6*codm = 167.819kg/day

Methane production based on the busswell Equation

Wch^4g = ch^4g×16/12 =104.801 kg/day

1 mole of gas is equal to 22.414 litres

16 kg of methane have 22.414 m^3

Moles of methane = Mol ch^4 = $wch^4g/16$ = 6.55 kg/day

Volume of methane = Mol ch^4×22.414 m^3/kg = 146.813 m^3/day

Heat combustion of methane or calorific value = 36×10^6 J/m^3

1 m^3 of methane generate 10 KW.

So the total energy generated by methane

Ech^4 = $Volch^4$×10 KW/ m^3

1.468×10^3 KW/ m^3

1. gas production rate:

One kg of undiluted food waste yields 0.25 m^3 of gas

Vg = 0.25 m^3/kg×Tfwg

=250 m^3/day

2. active slurry volume $Asv = \frac{Tfwg}{pw} \times HRT \times 2$

=40m^3

5.3 Project at a glance

No of digester	2
Usable digester pre digester volume	40 m^3
Usable secondary digester volume	80 m^3
Average retention time	12-15 days
Needed digester storage capacity	24 m^3
Total time required to install the project	3 months
Water consumed daily	Nearly 2000 liter
Organic loaded rate	450 kg at a time

Total manure	2000 MT
Water condition	Hot water (45^0c)
Ratio of water used to solid waste	1:1
Total power generated per day	180-240 KW
Total manure generated per day	Around 200 kg
Total man power required including security person	8 (1 skilled person + 1 plant supervisor + 1 electrician + 3 unskilled person +2 security)
Methane content in biogas	70-80%
Gas production rate	250 m^3/ day

Table: 5.1

Chapter-6

HAZOP study

Biomass is currently an emerging source of renewable energy. This helps a lot to reduce the use of nonrenewable energy. NIT Rourkela is planned to install a biogas plant to produce the electricity for hostel purpose. The plant is using cow dung and food waste and another biodegradable waste of the campus and it is having a good capacity of 2000 kg feedstock and designed to produce 180-240 KW power. So the role of safety is important here.

6.1 Processing hall

In the processing hall there will be a motor, crusher, a funnel for feeding. The input slurry is mixed here with water. The main hazard exist in the processing room is bio hazard. Fire hazard, mechanical hazard and electrical hazards.

Hazards	Recommendation
Bio hazard and ventilation	Provide 2 windows at the one opposite another. The dimension should be 1.5m×2.5m. provide 3 ventilators with exhauster fan.
Fire hazard	Though the fire hard is very poor here, to save the costly mechanical component it is important to make the room fire resistant. Proper ventilation system is there. Apart from that one gas detector, one fire alarm and a sprinkler system is there. At the out side of the room two dcp fire extinguisher along with three sand bucket are kept.
Mechanical and electrical hazard	The motor and the crusher is fully covered. There should be a emergency switch for the motor. All the the wires should be covered by non-insulating materials.

Table 6.1

6.2 Digester

It should have a volume of 10 m^3each with a center wall having 3’ opening at the bottom for free slurry movement (excavation, 9” rubbing soiling, P.C.C:- 1:3:6, brick work:- 1:5, plastering :- 1:4) and aeration grid (using 0.75” GI pipes of tata class) in both the compartments to provide aeration at three levels of equal intervals starting at 1’ above the bottom level. The pre digester will be covered by the slab of 4’’ thickness RCC with two manholes (3’ * 3’) cast in 5mm MS plate.

So as per the design total volume of the primary digester is 10 m^3.

As it is an aerobic reaction 10 % space should be given to digester.

So the liquid volume should be 9 m^3.

Density of the slurry is 50 kg/m^3.

So the maximum input material will be (50*9) kg

= 450 kg

The pressure at the bottom of is developed= 50 * 9.81 * 3

= 1471.5 kg/s

So the wall thickness should be resist this amount of pressure.

To prevent the fire hazard a fire point should be given at 10 m distance from the digester. The fire point must be equipped with 2 DCP fire extinguisher and three sand buckets.

Secondary digester:

The inlet mass to the main digester is 8 m^3.

Hydraulic retention time for the methanogenic reaction 10 day

So the minimum volume of the main digester should be 80m^3.

The joint of the slurry conveyer pipe between secondary to main digester should be air tight properly. And an ignition protection device should be given.

This is most vulnerable area of the plant as the fire hazard is very high here. So a fire point is provided equipped with 3 water fire extinguisher and four sand bucket.

Apart from that a water jet system should installed, connected with water supply source. The water source should have a capacity to supply the water continuously for 20 min at least.

A heavy water sprayer system, connected with smoke detector, should be installed near the solar water heater and a fire point should be given with

Calculation of efflux flow

Q_g =12 m^3/min

6.3 Risk area

Calculating the risk substance concentration

$$\text{Xr} = \frac{Qg}{Qa \times \rho gas} \times 100$$

$$= \frac{293 \times k \times LEL}{Ta} \times 100$$

= 4.7

The risk area consist of a plant of the environment i.e total risk zone

$$\text{Xm} \leq \frac{K \times LEL}{fa}$$

$$\text{Xm} \leq 52$$

Risk distance :

$$dz = Kz\left(\frac{42300 \times Qg \times fse}{M \times Kdz \times LEL \times Wa}\right)$$

= 76m

Calculation of risk volume:

$$\text{Vz} = \frac{fse \times Qa}{Co}$$

= 30 m^3

6.4 Emergency plan

The Main Objective of the Emergency Response Plan shall be preserving the life, property & Environment from the consequence of the emergencies arising within the site. Systematic coordination of emergency control action to arrest escalation of emergency to evacuate personal within or outside the site where necessary & to rehabilitate them. Restoring normalcy in site operation with minimum loss of time

So form the above calculation it is recommended an emergency shelter should be there 76 m away from the main digester. In general case the flame can come up to 52 m. so there should be a water hose connected with at least 250 liter water source. Most importantly there must not be any hostel or busy road in 52 to 60 meter radius from the main digester.

All the workers have to be trained for fire-fighting so that they can have a basic idea about how to operate fire extinguisher.

Chapter 7

Safety aspects

7.1 Risk and hazard

Production plants present three main risks:

- The hazard of explosion is the most concerned topic as it is associated to the use and production of a highly flammable gas which is composed with methane.

- The next foremost risk is toxicity due to the presence of H_2S. It is a very toxic gas that is produced in anaerobic digestion.

- The microbial risk is also to be considered, however chronic risk of inhaling pathogens and minor elements when using biogas is overshadowed by the two previous risks.

To fulfill the aim to construct a bio gas plant, following Nisargruna Technology, the process of installing and the maintenance should be well monitored in order to the prevention the hazards, managing the risk and prevent the exposure to that risk.

The biogas plant generally encountered by two main type of hazards:

i. Biological hazard
ii. Fire hazard

7.1.1 Biological hazard:

Bio-chemical-hazard related to biogas plant technology may be encountered by the feedstock and the digestive. Slurry of animals and human origin encompass various pathogenic bacteria (e.g Salmonella, Enterobacter, Clostridia, Listeria ecc), parasites (e.g. Ascaris, Trichostrangylidae, Coccidae), fungi, viruses (Ritari et al. 2012, Sahlstrom 2003). These bacteria could cause an occupational and environmental biohazard. Biogas generation from co-digestion of animal manure and biodegradable wastes should not result in new routes of pathogens and diseases transmission among animals, humans. It can be controlled by standardized sanitary and veterinary controls.

The hazardous substances, are produced in this technology are-

Processing aids (essential nutrients), compounds for desulfurization= hazard of carcinogenic substances, toxic hazard, In the Ordinance on Bio-substances, biological agents.

7.1.2 Fire hazard

Biogas plants process in large scale deals with highly combustible and toxic gases. So any big accident regarding fire and explosion can take place in order to any fault in design, material or control. Methane, the main product of this process, is highly flammable and cause explosive mixtures while it composed with the oxygen in the air in proper portion. Therefore explosion protection is noteworthy factor in biogas plants. Apart from methane H_2S is also a by-product of this plant which is also same flammable. So proper safety control and policies must be implemented during construction, maintenance and operation of biogas plants.

Apart from that there are also some another type of hazard may encountered.

7.1.3 Electrical hazards

The main electrical hazards present in the whole system are

Defective electrical equipment or electrical lines; defective lightning protection, defective electrical installations.

Recommendation

i. All the electrical wire must be covered by non-insulator material coding.
ii. The generator area should be barricaded. No authorised person is allowed to enter that area.

7.1.4 Mechanical hazards

There are not so much mechanical hazard. In processing room there are some mechanical components. Apart from that during the construction, maintenance mechanical hazard can take place. Falling from in to tanks, construction area, silo, ladder.

7.1.5 Gas hazards

Element	Bio-gas
Mithene	50-75%
Carbon di oxide	25-45%
oxygen	2-4%
Hydrogen sulphide	<0-6 ppm

Table:7.1

So the main concern should be taken for hydrogen sulphide and methane. Hydrogen gas caused a wise and severe range of health effect. The workers are exposed to this gas by means of breathing. The consequences of the exposure depends on the duration of the exposure. But a long exposure to this gas can cause fatality by breathing problem. Methane gas doesn't have any adverse health effect. It is a colorless gas and having no odor or bad smell. But it is having high flammability which can cause a big fire hazard whenever it comes to contact with any fire source. As it is very difficult to detect the leakage the risk of fire explosion is very high where a large amount of biogas is produced.

7.2 Explosion range of biogas

The explosion range any fuel mixtures can be represented perfectly by a graphical triangle named "triangular diagrams". In a triangle each side represents the binary mixture of fire and the three corners represents the respective pure substances. The diagram revealed the mixture composition very clearly. If the explosion diagram of methane-vs-carbon dioxide-vs-air is plotted we will easily get the explosion limit of methane. The lower and upper explosion limit of methane in air are represented on the left side of the diagram. In this case the values will be LEL = 4.3 mol% and UEL = 16.3 mol%. The limiting oxygen concentration can be determined by the air fraction of the apex of the explosion area. The air fraction is evaluated with 65 mol%. This corresponds to an oxygen concentration of 13.6 mol%. Some basic statements can be generated by using these data. Whenever a leakage or any accidental leakages take place in biogas plant, the only possibility to get explode if the methane concentration exceeded lower explosion limit. Apart from that, it is also possible to obtain an explosive mixture if the air ingress into a biogas vessel and the LOC is exceeded. The level of oxygen concentration of 13.6 mol% refers to a dry biogas,

in which the water vapor portion is negligible. For the secondary digesters, where the biogas contains major portion of water vapor at temperatures up to 50 °C, the LOC drops down to 12.4 mol%.

Calculation of explosion limit:

The lower explosion limit

$$\text{LEL} = (1 + \frac{Xco2}{Xch4}) \times LELch4co2$$

So the lower explosion limit from the equation LEL(30/70) = 6.3 mol%

LEL (50/50) = 9.2 mol%

The upper explosion limit

$$\text{UEL} = (1 + \frac{Xco2}{Xch4}) \times UELch4co2$$

So the upper explosion limit from the equation UEL(30/70) = 19.7 mol%

UEL (50/50) = 23.2 mol%

7.3 Occupational health aspects

Though according to the Italian Decree 81/2008 no special protection devices are required badly, but the observance of hygiene regulations is critically significant during work and maintenance in biogas plants. If the quantified hygiene measures and other protective controls are properly taken, any hazards are not normally encountered. However if employees suffer any occupational health problems like headaches, dizziness, diarrhoea or skin irritation, the workers and efficacy of the protective control must be immediately tested. Any personal hygiene measures include the disinfection or washing of hands before breaks. The work-place (plant area) must be non-smoking zone and eating and drinking is not allowed near the processing room or when the segregation is carried out. The apron for working must be separately stored from private clothing in accordance with good practice for preventing the propagation of pathogens. A skincare plan is also important. It includes the provision of facilities for washing and disinfection, and of skin protection and care products. Furthermore employees must receive instructions on hazards and protective measures before assuming their tasks and subsequently at regular intervals. In biogas

plants, during the different operations (biomass storage, loading and unloading) workers could be exposed to bacterial endotoxins. Acute lung function changes, which are associated with endotoxin levels, have been measured in different occupational environments: pigs farming, animal feed, grain processing, waste and compost industry, and agricultural seeds (grass, cereal, or vegetable). The source of endotoxins is the lipopolysaccharides (LPS) in the cell walls of Gram-negative bacteria derived from decaying wastes. At low concentrations i.e. less than 200 Endotoxin Units (EU)/m3), endotoxins can induce fever, and at high concentrations (>200 EU/m3) a stimulation of the mucous membrane; respiratory diseases up to chronic inflammations of the respiratory system can be evoked. Relatively low endotoxin levels of 50-500 EU/m3 over 8 h may cause a decline in lung function. An exposure limit of 50 EU/m3 has been recommended (ICOH 1997).

7.4 Conveying food waste and another waste

According to Nisargruna Technology food waste, another kitchen waste and biodegradable waste like dry leaves, are considered as input material. So every day food waste will be collected from all hostels and canteens. The waste from the hostel will be collected by mini truck to the processing room. To make the segregation easier the hostel caterer will be provided two different dustbin for biodegradable and non-biodegradable waste. And it is ordered strictly to throw the waste to the dustbin accordingly. There will be a separate road for truck to convey the waste and which will be generally avoid to use for general transportation purpose. The transportation time should be when the road was not too busy.

7.5 Safety measures for segregation

The quality of the methane produced is significantly depended on the segregation process and the proper input materials. So the segregation of biodegradable material should very proper in order to produce a high quality biogas. At the time of segregation the bio hazard is the big concern. As it is segregated manually the workers are directly exposed to the bacteria. So the effective control measures are-

i. Livestock health control- No animal manure and slurries should be supplied from any livestock with health problem.

ii. Feedstock control- Biomass types with high risk of pathogen contamination must be excluded from aerobic digester.
iii. All the workers including segregation plant maintenance work, manure collectors must be provided proper ppe.

Generally three PPEs are require for the whole process

i. Hand gloves: there are no such vulnerable contaminant reacts with rubber. So the light weight rubber, plastic or simple cotton gloves can be suggested for the whole process. But as any electric difficulties can come it is better to afford rubber gloves (IS4770).
ii. Full body apron: simple light weighted cotton apron (HS63079090 is suggested for the segregation operation.
iii. Nose mask: simple nose mask can be used for the segregation. But at the time of maintenance of digester tank proper respiratory protection has to be taken.

According to the ICOH 1997 no worker will be exposed in segregation work continuously for 1 hour.

7.6 Checklist

7.6.1 Checklist for daily work

Conditions	yes	No
All electrical connections and equipment are checked by the electrician		
Illumination of the processing room is greater the 60		
The workers are provided all the recommended ppes		
Toolbox talk is given		
By product waste manure are cleared out.		
The cover of the crusher is locked.		
The sensor in AD and SD is working properly.		
Solar panel, manure pits are barricaded.		
All the fire fighting equipment are inn workable condition		

7.6.2 Monthly checklist

Parameter	Yes	No
Maintenance of digester is done		
The condition of electric connection are checked		
Maintenance the sand filter		
Check sprinkler and gas detectors.		
Clean the crusher and pipes.		

7.6.3 Checklist for maintenance work

Parameter	Yes	No
All the electrical connection is closed		
Environment in the digester is not flammable under normal condition		
No ignition source is present near the digester		
Adequate oxygen level is present in the digester		
The workers are provided all the PPEs required		
All the fire fighting equipment are in workable condition		
An ambulance with a medical team is present for the medical emergency.		

7.7 Threat zone

Site data

Location: Rourkela, India

Building Air Exchanges Per Hour: 1.32 (unsheltered single storied)

Time: May 22, 2016 0124 hours ST (using computer's clock)

Chemical data

Chemical Name: METHANE

CAS Number: 74-82-8 Molecular Weight: 16.04 g/mol

PAC-1: 65000 ppm PAC-2: 230000 ppm PAC-3: 400000 ppm

LEL: 50000 ppm UEL: 150000 ppm

Ambient Boiling Point: -259.0° F

Vapor Pressure at Ambient Temperature: greater than 1 atm

Ambient Saturation Concentration: 1,000,000 ppm or 100.0%

Atmospheric data: (manual input of data)

Wind: 6 meters/second from SE at 3 meters

Ground Roughness: open country Cloud Cover: 5 tenths

Air Temperature: 38° C Stability Class: D

No Inversion Height Relative Humidity: 36%

Source strength:

Leak from hole in vertical cylindrical tank

Flammable chemical is burning as it escapes from tank

Tank Diameter: 3.57 meters Tank Length: 3 meters

Tank Volume: 30 cubic meters

Tank contains gas only Internal Temperature: 50° C

Amount of Chemical in Tank: 35 cubic meters

Circular Opening Diameter: 5 inches

Flame Length: 11 yards Burn Duration: 20 seconds

Burn Rate: 3.62 pounds/sec

Total Amount Burned: 13.7 pounds

Jet fire:

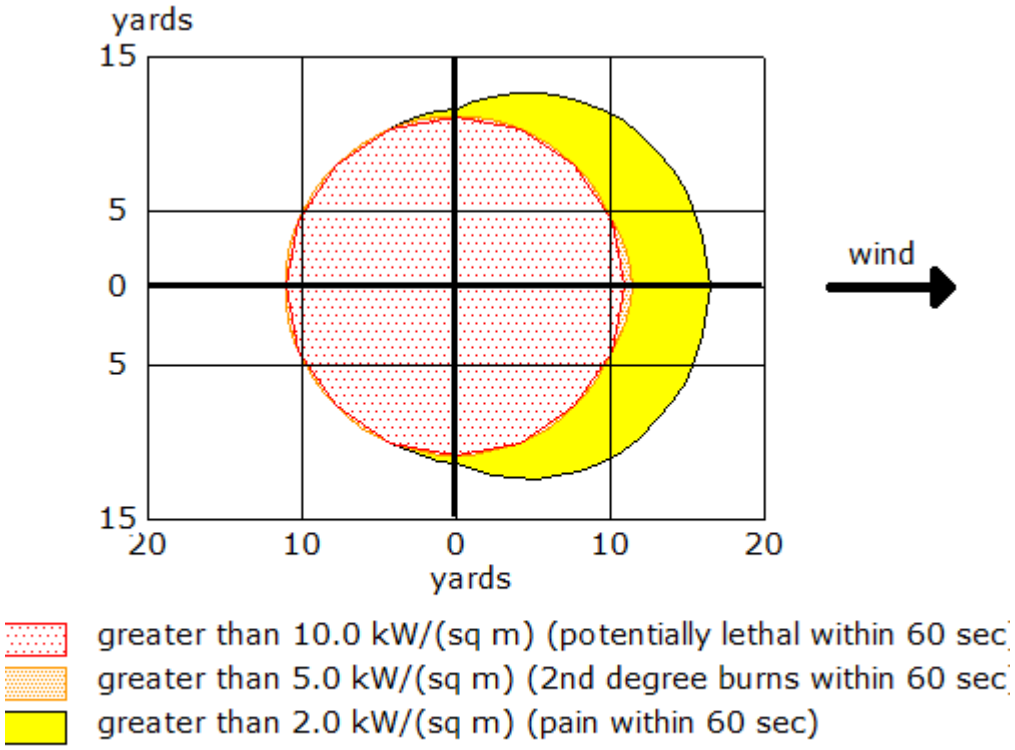

Fig 7.1 Threat zone due to jet fire

Flammable Area of Vapor Cloud

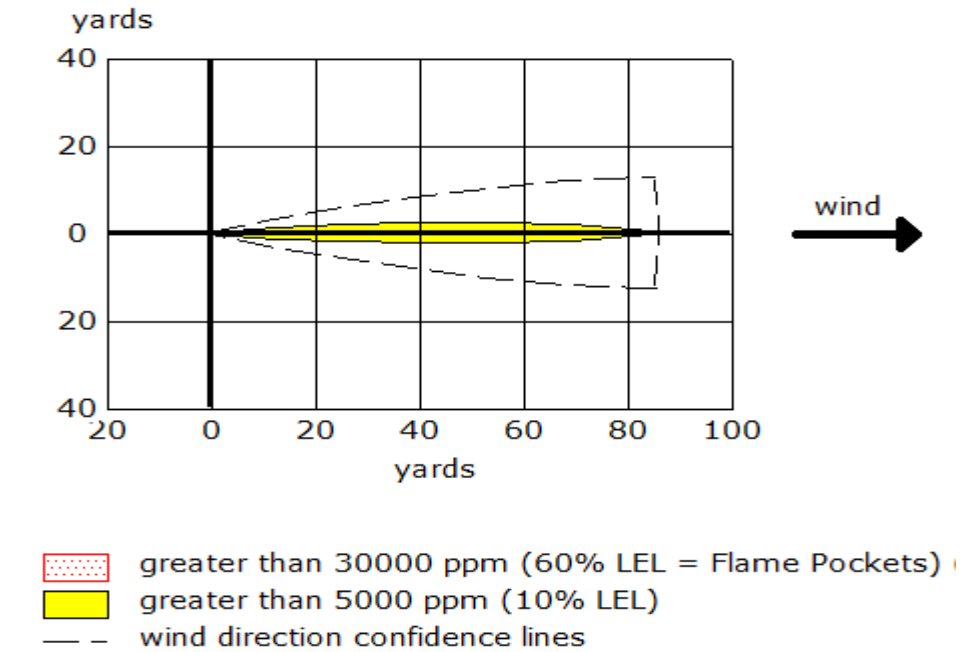

Fig 7.2 Flammable area due to vapor cloud.

Over pressure blast-force threat zone:

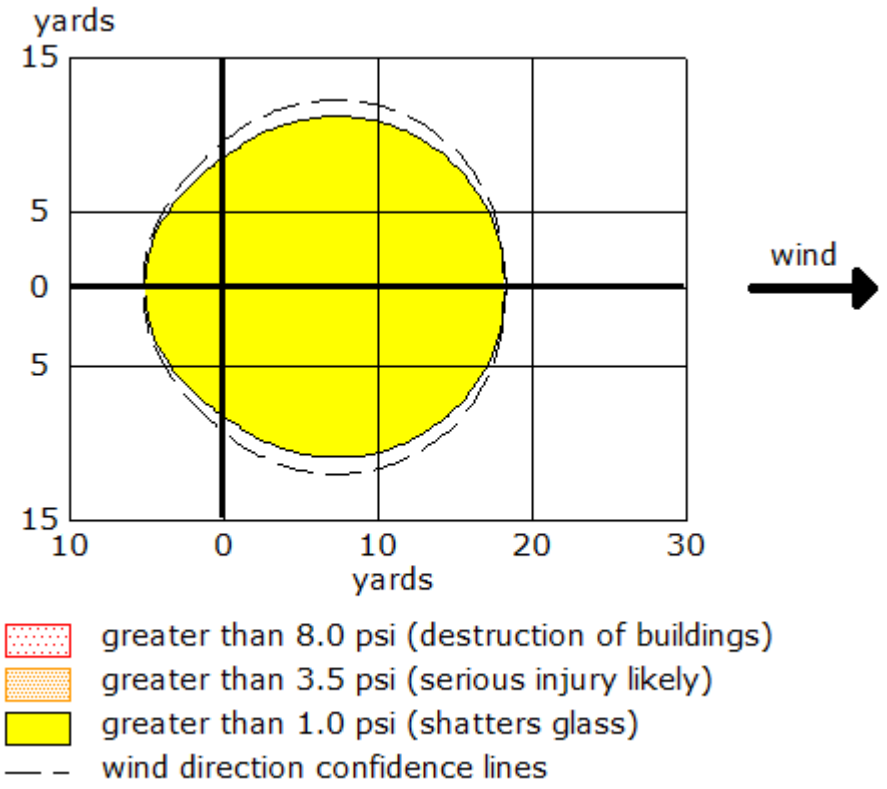

Fig 7.3 Over pressure blast force threat zone

Night condition:

Atmospheric data changed: wind speed 8 m/sec and humidity 56%

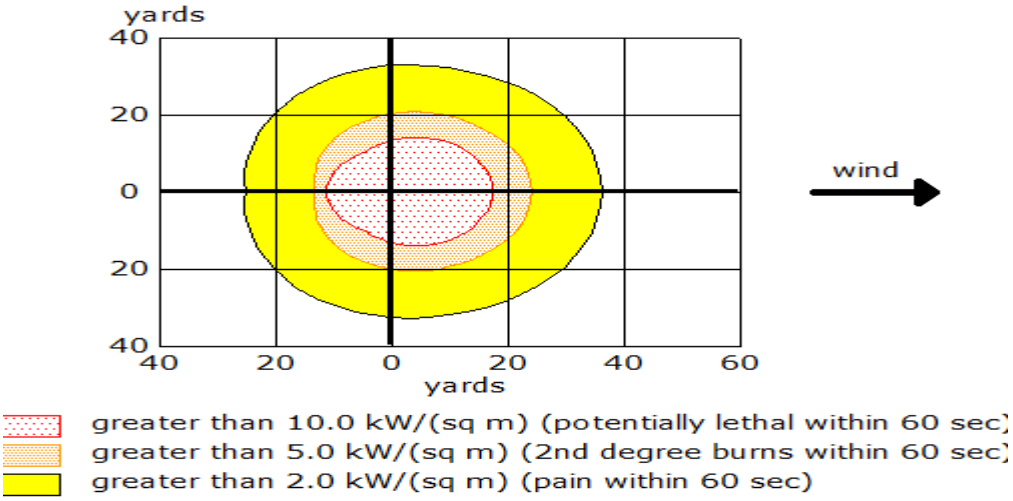

fig 7.4 threat zone due to jet fire at night.

over pressure blast force from vapor cloud explosion

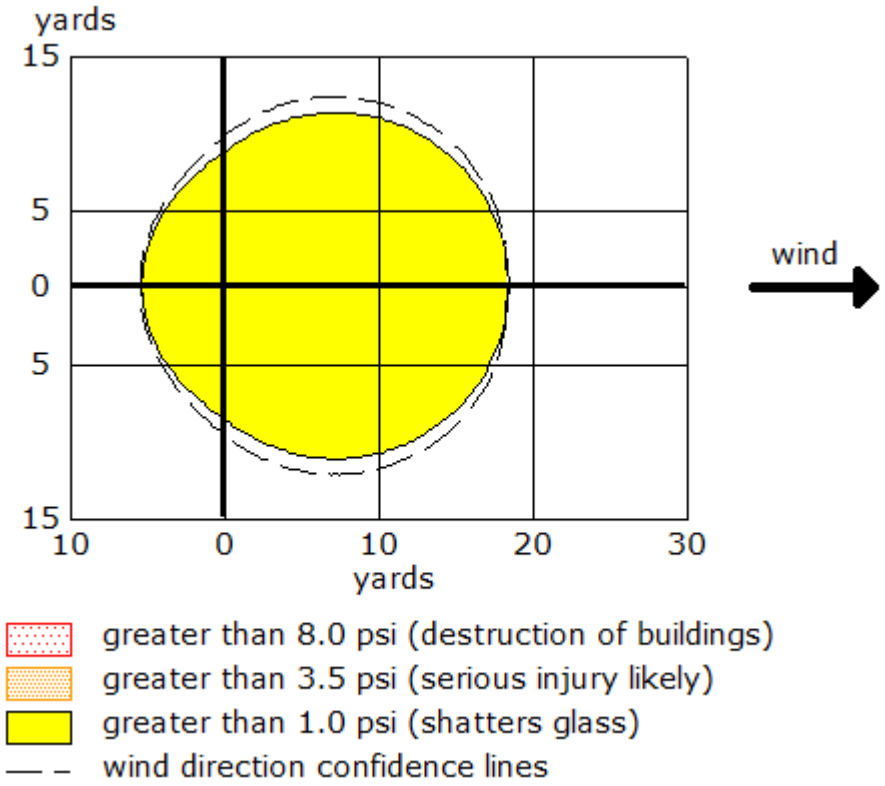

Fig: 7.5 Threat zone of over pressure blast force at night

Chapter 8

Advantages and disadvantages

Advantage of nisargruna technology

1. Easy to maintain the plant.
2. System is designed indigenously in India; and does not consist of any expensive imported components, thus ensuring easy availability of spares.
3. Most sub-operations does not require high skill. Workers can be trained for plant operation in 3 months.
4. Can be more efficient when waste input is good quality of segregated waste.

Disadvantage of the technology

1. Most of the operations are manual and no mechanical operations involved in the system, pre-digester system needs manual operation of feeding the slurry further to the pre-digester from the inlet channel. Aesthetically it may not look good.
2. Hot water in the pre-digester needs to be poured manually.
3. There was bad odour at the plant. It might disturb neighbours and dwellers as well as other visitors too.
4. Sludge holding tanks showed bubbles, which indicates that there might be some anaerobic conditions, which is due to incomplete digestion of the slurry.
5. There is no proper shredding or cutting of the waste in the mixer, it only homogenizes with water but doesn't get crushed by the blades. Digestion will be faster with properly crushed waste.

Chapter 9

Conclusion

Where the pollution is a big concern of the modern world and solid waste management is part of that aspect, this type of initiatives taken by NIT Rourkela is a motivational approach to overcome the environmental challenges as well as it is also generating electrical energy from biomass energy.

It will take around 3 months to install the complete set up. The total expenditure of the project goes up to maximum 32 lakh including commissioning. And as the biogas is converted into electricity power it needs a gas generator and a scrubber. So for the generator and its accessories the budget will be 10 lakh. So the total cost will be around 40 lakh initially. Now every day it will generate 180-250 KW power and around 200 Kg rich manure. That means rs 900 for electricity (unit@ rs 5) and the manure worth is rs 400 (@ rs 2 per kg). Total we can earn around 1300 per day.

If we see from the environmental aspects, then also the total process is echo friendly. If any accidental leakage does not take place then this process can run very safely for long day. From the graph of risk zone it is clearly understood that the main risk zone is around 30 m^3. And if the gas leaks for one min without burning it can covered above 70m distance.

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